

September 15, 2011

VIA ELECTRONIC FILING

Marlene H. Dortch, Esquire
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: Notification of *Ex Parte* Presentation
LightSquared Subsidiary LLC, Application for Modification of
Authority for Ancillary Terrestrial Component
(File No. SAT-MOD-20101118-00239)
LightSquared Subsidiary, LLC, Technical Working Group Report
(IB Docket No. 11-109)

Dear Ms. Dortch:

This is to advise you, in accordance with Section 1.1206 of the FCC's rules, that on September 13, 2011, the representatives of the GPS community listed on Attachment A met with the individuals from the Commission listed on Attachment B. At the meeting, the attached documents were provided.

The FCC participants first expressed an interest in discussing the effects that LightSquared Subsidiary, LLC's ("LightSquared") proposed high powered terrestrial broadband network may have on Trimble Navigation, Ltd.'s ("Trimble's") high precision products. The parties discussed the design of high precision receivers and various configurations of the component parts depicted in Trimble's handout as well as differences in communications transmissions and navigation-related transmissions. Trimble representatives provided Commission staff with information regarding how various components were affected by interference from the proposed operations of LightSquared. They also addressed the need for the FCC to consider GPS device reception of signals from other than U.S. satellite systems. The parties discussed the fact that additional details regarding LightSquared's most recent proposal would be required, along with further testing, in order to make a more complete assessment of that plan. The parties noted that even under LightSquared's proposed plan, the embedded base of Trimble high precision devices would continue to suffer devastating interference.

The Garmin representatives provided background on the FAA process of certifying GPS devices used in aviation. They also discussed additional testing that they thought should be performed on general location/navigation and aviation GPS devices.

After Dr. Hegarty and the Garmin participants left the meeting, the Trimble participants and FCC representatives discussed the filing that Trimble made on August 22, 2011, with a request for confidential treatment, regarding the Trimble devices that were tested as part of the Technical Working Group ("TWG") process evaluating the impact of LightSquared operations on GPS receivers. The Trimble representatives answered FCC staff questions about the information it provided with respect to those devices.

If you have questions about this submission, please contact us.

Very truly yours,

/s/

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Glovsky and Popeo, PC
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Very truly yours,

/s/

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Counsel to Garmin International, Inc.

Attachments

cc w/o attach. (by email):

FCC Participants on Attachment B

Attachment A –GPS Community Representatives

Mr. Scott Burgett, Garmin International, Inc.

Mr. John Foley, Garmin International, Inc.

M. Anne Swanson, Esquire, Dow Lohnes PLLC (representing Garmin)

Dr. Chris Hegarty, MITRE Corporation

James A. Kirkland, Esquire, Trimble Navigation, Ltd.

Mr. Bruce Peetz, Trimble Navigation, Ltd.

Mr. Stuart Riley, Trimble Navigation, Ltd.

Russell H. Fox, Esquire, Mintz Levin (representing Trimble)

Attachment B – FCC Participants

Mr. Julius Knapp
Chief, Office of Engineering and Technology

Mr. Ron Repasi
Deputy Chief, Office of Engineering and Technology

Mr. Walter Johnston
Chief, Electromagnetic Compatibility Division, Office of Engineering and Technology

Mr. Robert Weller
Chief, Technical Analysis Branch, Electromagnetic Compatibility Division, Office of Engineering and Technology

Mr. Michael Ha
Office of Engineering and Technology

Mr. Steven Jones (via telephone)
Office of Engineering and Technology

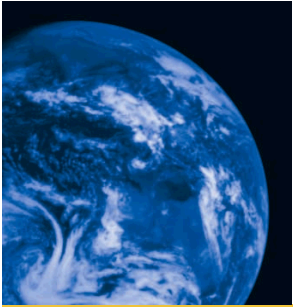
Mr. Brett Greenwalt
Office of Engineering and Technology

Mr. Chip Fleming
Engineering Branch, International Bureau



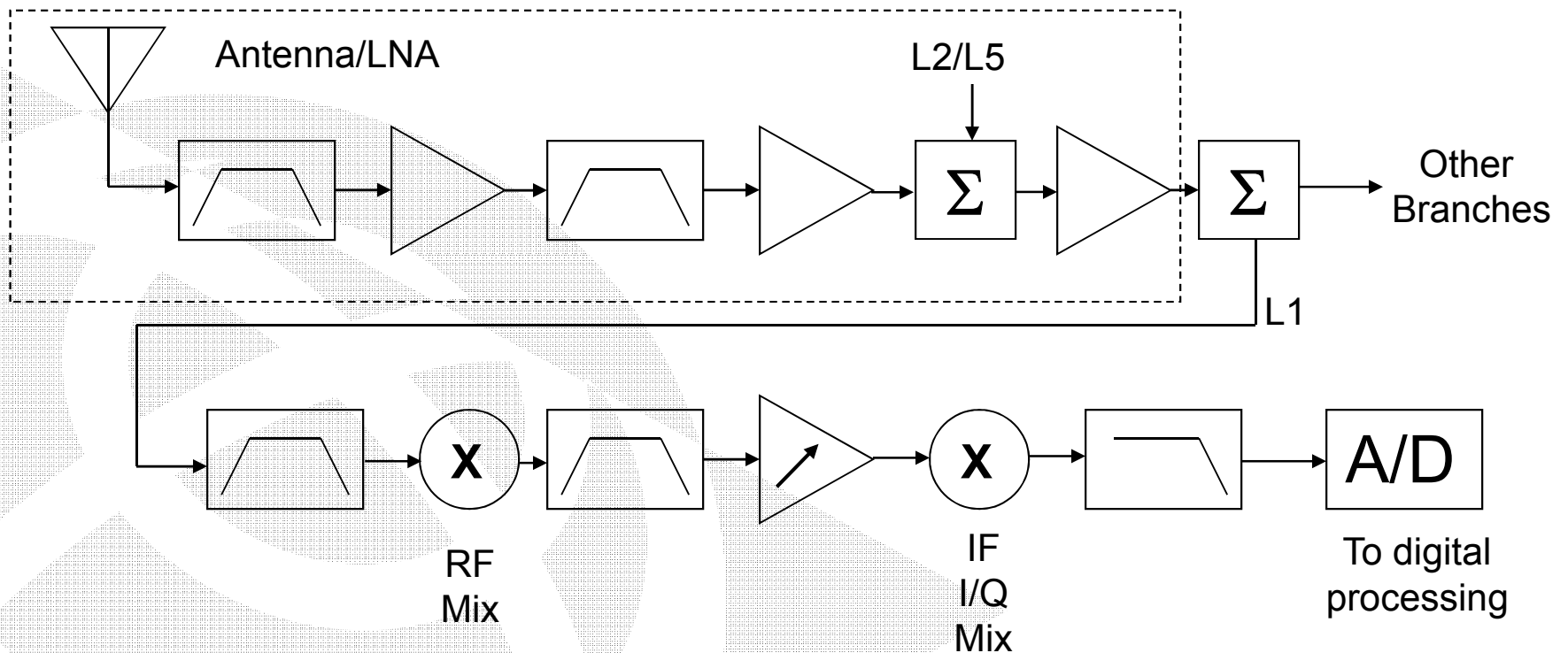
Precision GPS and Terrestrial MSS Broadband

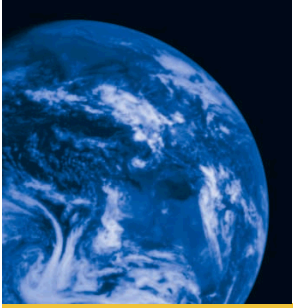
Presentation to the FCC
13 September 2011



Precision Receiver Design

Simplified L1 RF Chain shown





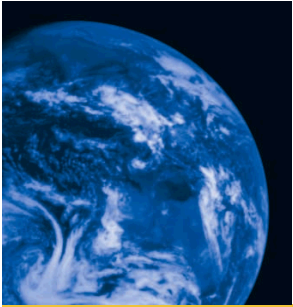
The fundamental differences in Radio Communications and Radio Navigation are central to this issue

▪ Digital Radio Communications:

- Incoming message is not known – finding it is the whole point
- Must determine whether each signal “bit” is a one or a zero
- Use sophisticated methods to correct errors

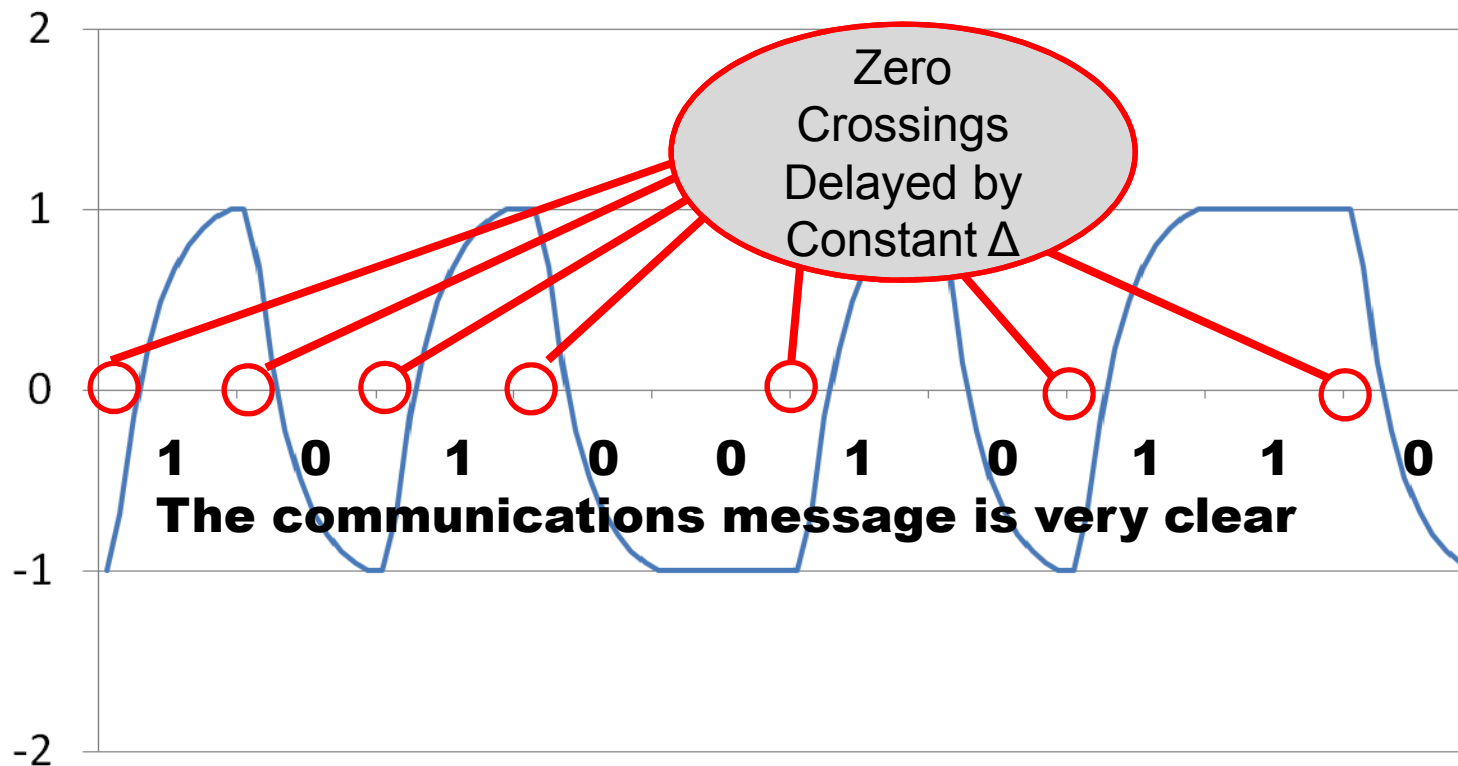
▪ Digital Radio Navigation:

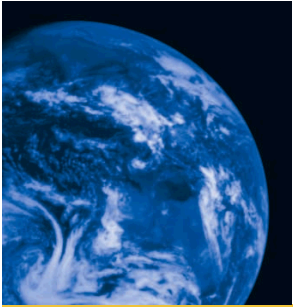
- Incoming signal sequence (ones and zeros) is known by user
- The goal of the user is to precisely time the transition from one to zero (and zero to one)



Without Noise, a *narrow band* receiver would give consistent results. Unfortunately the GPS band is dominated by natural noise.

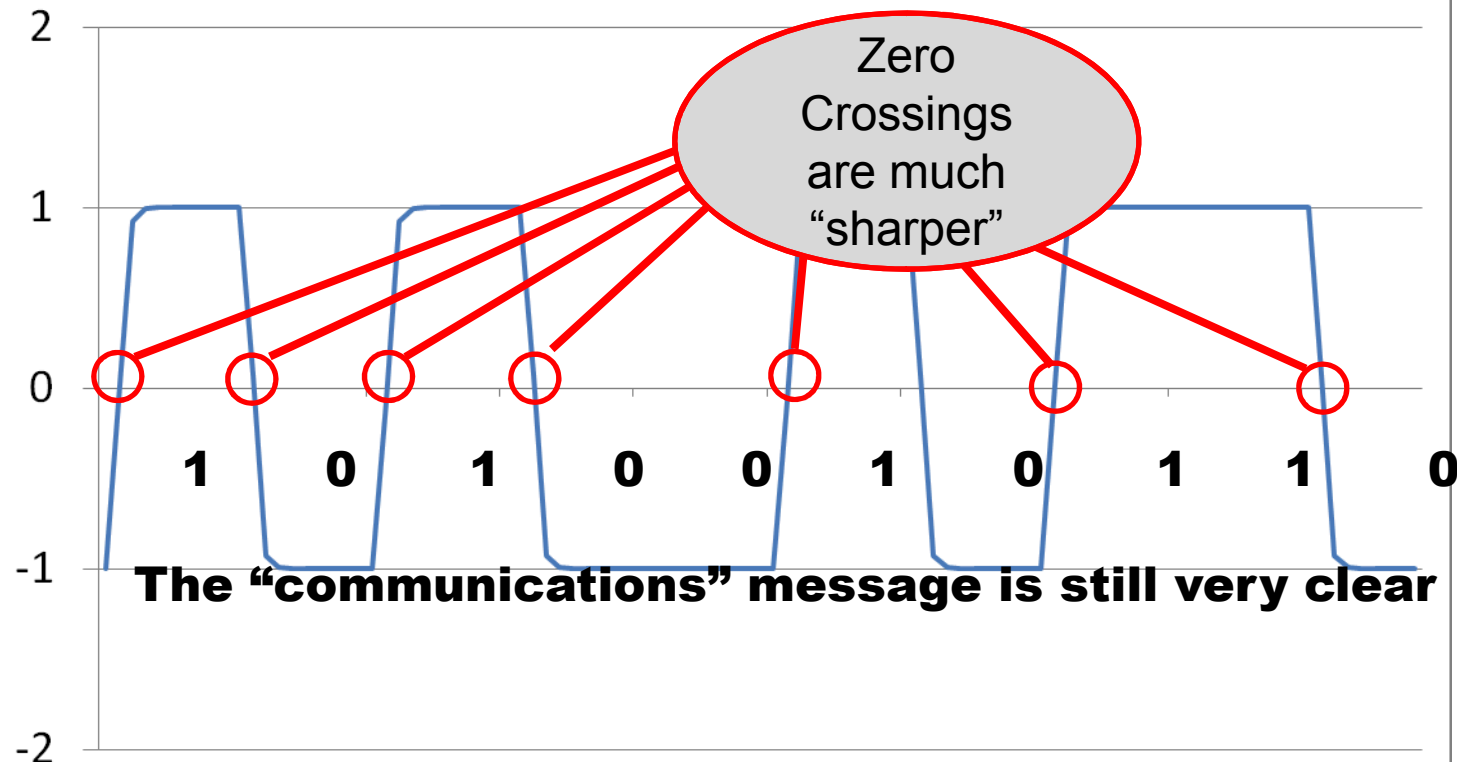
Received Noise-Free Data (Narrow-Band GPS Receiver)

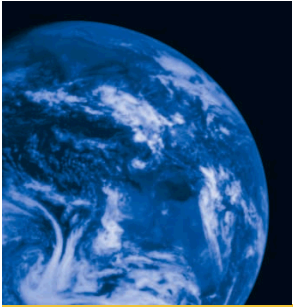




Without Noise, a Full-Band GPS receiver has much sharper transitions. This helps compensate for radio noise.

**Received Noise-Free Data
(Full- Band GPS Reciever)**



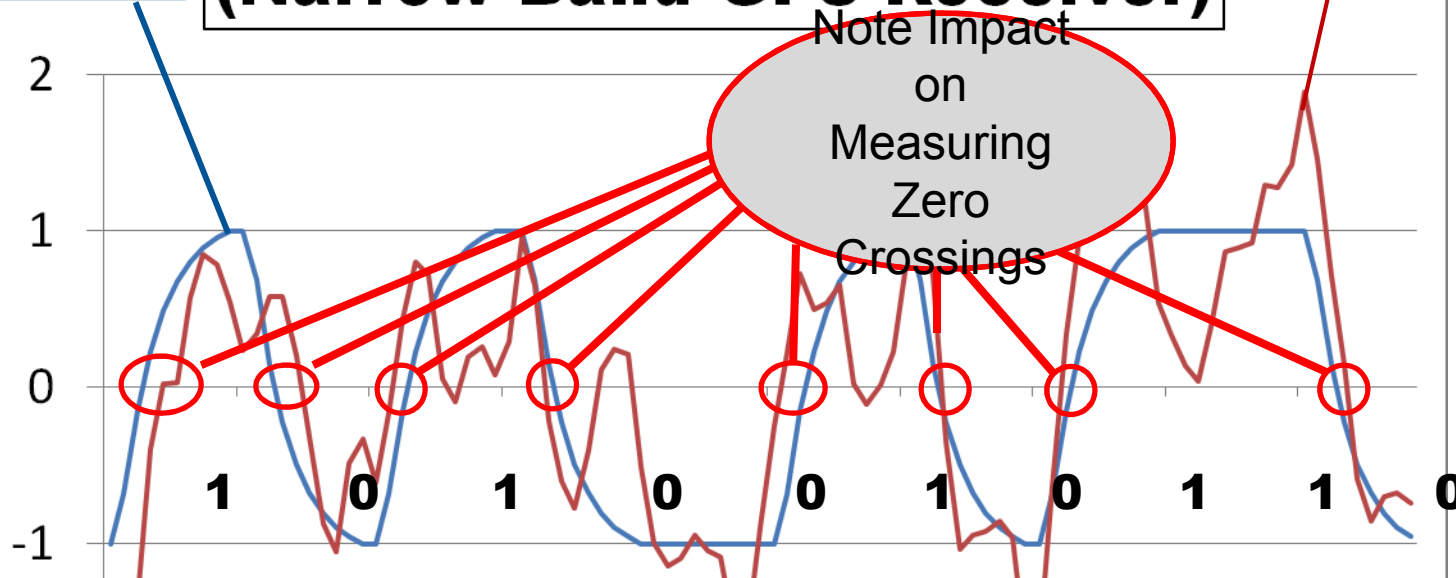


Unfortunately, natural radio noise causes much uncertainty in zero crossings for Narrow Band Receivers

Noise free
signal in
Blue

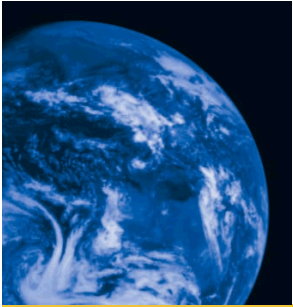
**Received Data With
Nominal Noise
(Narrow-Band GPS Receiver)**

Received
Signal in
Red



Note Impact
on
Measuring
Zero
Crossings

- Inaccuracy in measuring the transition corrupts the estimate of range to the satellite, and creates substantial errors in finding position
- Note that the communications data can still be read (0s and 1s)

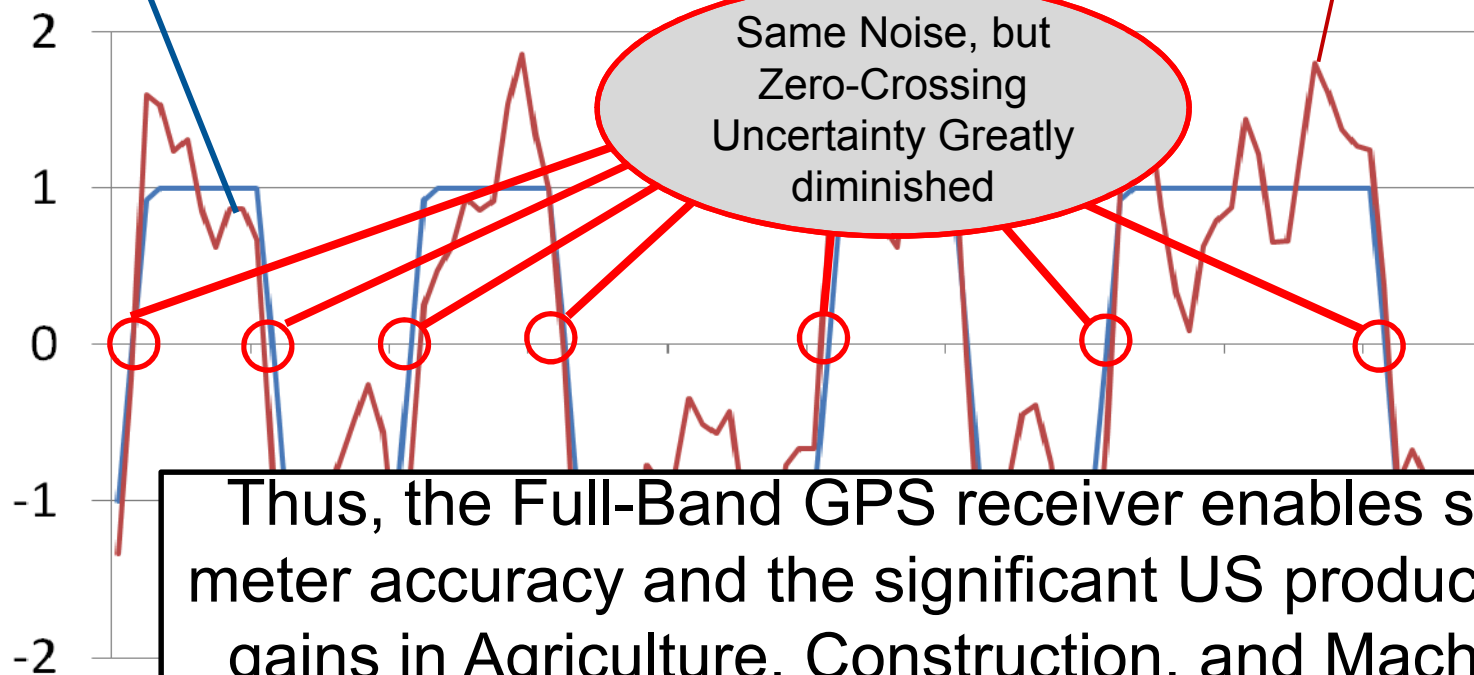


To achieve maximum accuracy, a Full Band GPS receiver has sharper transitions, reducing the effect of noise and allowing a more precise timing measurement

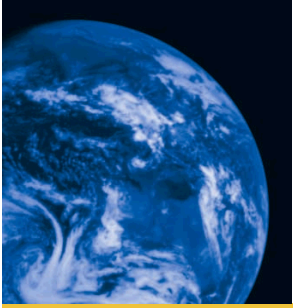
Noise free
signal in
Blue

**Received Data With
Same Nominal Noise
(Full-Band GPS Receiver)**

Received
Signal in
Red



Thus, the Full-Band GPS receiver enables sub-meter accuracy and the significant US productivity gains in Agriculture, Construction, and Machine Control

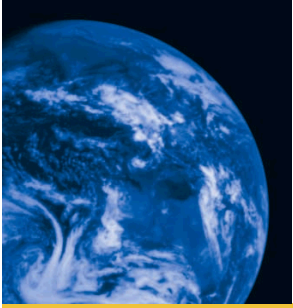


So the brief answer to: Why does Hi-Performance GPS need *Full-Band Receivers*?

- Using Full-Band, the timing uncertainty used for the basic GPS ranging measurement is greatly improved
- This is essential for the sub-meter accuracy that is the basis for many of the Productivity-enhancing applications credited with 10s of Billions of Dollars in annual savings

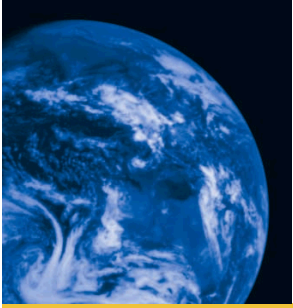


**Full-Band GPS is similar to a fine telescope.
Without Full-Band, the signal is not well focused**



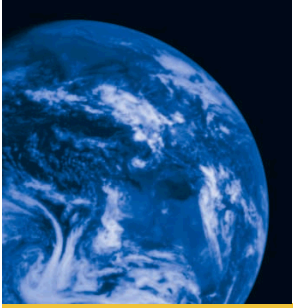
GPS is always in fringe reception and requires high sensitivity

- **All reception margin is dedicated to**
 - **Low elevation satellite reception (to minimize Dilution Of Precision) and**
 - **Overcoming loss due to partial obstructions (such as trees), while**
 - **Maintaining adequate signal-to-noise for accurate measurements**
- **Consequently precision GPS receivers are designed to minimize noise figure**



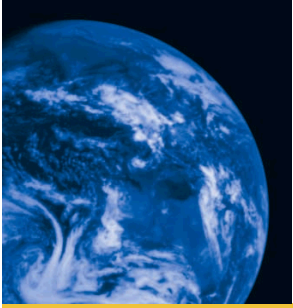
Wireless broadband creates the most challenging interference environment of any service

- **Shannon's Law $C = B \log_2(1+S/N)$**
- **Bit Density $C/B = \log_2(1+S/N)$**
- **Power at the receiver must increase exponentially compared to bit density**
- **LTE goal is $>30\text{b/s/Hz}$; but using 20b/s/Hz**
 - **Would require 93dB more power than MSS (satellite) at $.5\text{b/s/Hz}$ at the receiver**
 - **Would require 80dB more power than digital television at 3.3 b/s/Hz at the receiver**



Observations on LSQ proposals of September 6 – Power on the ground

- A welcome development that could obviate the need to specify tower height, antenna downtilt, and to agree on propagation models
- Needed to fill out this approach:
 - Validate appropriate power levels (vs proposal of -30/-27/-24), and codify them in the rules
 - Define LTE duty cycle at which power measurements are to be made
 - Validate averaging area of measurement
 - Ensure protection for aviation and space
 - Power on the ground doesn't necessarily correlate to power in the air
 - Establish the measurement density
 - No use of the upper band



Observations on LSQ proposals of September 6 – Filter Development

- **Of limited value**
 - **Equipment cannot be designed to typical values; need to take mfg variance, temperature variation, etc. into account**
 - **Detailed design and test requires parts, not a simulation**



Garmin Response to Latest LightSquared Proposal



September 13, 2011

No Solution for Aviation

The LightSquared proposal does nothing to address the Aviation interference issues with the lower 10 – it may make things worse.

- **It is not clear that limiting the “power-on-the-ground” does anything to reduce the aggregate interference received by an aircraft in flight.**
 - The analyses of the effects of the LightSquared transmissions on airborne GPS are based on an assumption of a base station transmit power of +62 dBm.
 - The latest proposal does not change this, it only suggests that the transmit power could be reduced or the antenna downtilt could be changed if the measured “power-on-the-ground” exceeds the limits.
 - Reducing the “power-on-the-ground” by reducing ATC antenna downtilt may actually increase the amount of RFI seen by an aircraft in flight.
 - “Power-on-the-ground” is not relevant to aircraft in flight.

Basic Ground Rules

Any possibility of LightSquared's proposal being acceptable for General Location/Navigation and Aviation is contingent upon at least the following requirements:

- Aviation receivers are certified to be compatible with all aspects of the proposed LightSquared system
- The definition of “harmful interference” is agreed to be 1 dB of C/N_0 degradation
- High power terrestrial use of MSS spectrum above the “lower 10 MHz” (1526 MHz – 1536 MHz) is specifically prohibited by the FCC
- LightSquared's “voluntary” reduction in maximum transmit power to 62 dBm EIRP is embodied in its FCC authorization

Independence and Transparency Required

Oversight of LightSquared's proposed power level monitoring process is required

- Independence and transparency required for the power level monitoring function. FCC oversight required
- Corrective action when high power detected should be subject to review, and later independently verified.
- FCC enforcement action should ensure noncompliant instances are corrected and not allowed to repeat

The Way Power Is Sampled Is Deficient

LightSquared's power monitoring protocol has serious problems

- Does not control interference power in the air – thus no solution for Aviation receivers
- Power monitoring begins at 50 meters from the base of the tower or “closest practical point”
 - Many towers are sited such that vehicle traffic can frequently come within 50 meters of the tower and still be in the beam of the transmit antenna
- Up to 5000 measurements will be collected, but no spatial sampling requirements are given
 - The samples could all be taken in areas where the power is relatively low due to terrain, building obscuration, etc
 - Areas with good line of site exposure to the tower (and hence high power) could be ignored

Better Procedures for Sampling Power Required

LightSquared's power monitoring protocol has serious problems (cont)

- LightSquared proposes to sample “up to 500m from the base of the tower.”
- Using free space propagation and 62 dBm EIRP transmit power which is LightSquared's proposed maximum, the -27 dBm power radius is 433m. For -24 dBm, the radius is 306m.
 - If all points are sampled at ~500m from tower, the likelihood of measuring these higher powers (-27, -24) is greatly reduced because of path loss
 - A uniform way to spatially sample the area around the tower is required to make sure high powers are detected

Verifying High Power Areas Extremely Vague

LightSquared's power monitoring protocol has serious problems (cont)

- The procedure for verifying the point of highest power is extremely vague
 - 10 measurements are taken within a 10m by 10m square, then measurements averaged in dBs
 - Averaging dBs is not accurate when there is a large variation in measurement values
 - The local minimum power in the square could be sampled 10 times to give a false low reading

Corrective Actions May Make Problem Worse

LightSquared's "Corrective Action" plan is insufficient

- Adjusting downtilt of transmit antenna changes the entire power environment of coverage area
- Because of this, other areas may be over the power limit, perhaps in a neighboring cell
- Adjusting downtilt could significantly change the power aloft, affecting Aviation GPS receivers
- Reducing base station transmit power is the most effective corrective action

Universal Filter Is Not Universal

“Universal Filter” proposal is not relevant to Aviation GPS

- Not workable as a retrofit solution and may not be suitable for a forward-fit solution to existing aviation receivers.
 - Units with antenna & receiver integrated into a single unit cannot be retrofitted
 - Unlikely if Avago filters can meet stringent environmental requirements for certified installations

Needed Improvements to LightSquared Proposal

Aviation concerns must be satisfied

The power monitoring protocol must be strengthened

- The FCC or other regulatory body must monitor the process to ensure independence and transparency
- The area around the tower should be sampled in a way that provides uniform coverage of the entire service area
- There should be no minimum distance from the tower restriction
- The procedure for verifying an over power sample is not adequate
- The power monitor data should be made available to the GPS Industry (or the public)



General Location/Navigation GPS and Terrestrial MSS Broadband



September 13, 2011

Executive Summary

LightSquared's Lower 10 MHz Proposal Raises Significant Concerns For General Location/Navigation (GLN) Devices

- The Lower 10 MHz Proposal Interferes with the Installed User - Base
- The Technical Working Group (TWG) Tests on the Lower 10 MHz Were Insufficient to Prove that Harmful Interference Will Not Occur.
- The Upper 10 MHz Is Still Under Consideration
- The Handset Issue Has Not Been Studied Sufficiently
- The Lower 10 MHz Proposal Raises Concerns for Modernized GPS Signals

Problems with Lower 10 MHz

The Lower 10 MHz Proposal Interferes with the Installed User - Base Of General Location/Navigation Devices

- Dispute over the definition of harmful interference: C/N_0 degradation
 - GPS community using 1 dB of C/N_0 degradation
 - 1 dB is well supported in the interference analysis literature (NTIA, ITU)
 - LightSquared suggesting a 6 dB C/N_0 degradation
 - 6 dB is arbitrary and seems to have been selected “post testing”
 - 6 dB has no precedent in interference analysis literature

Problems with Lower 10 MHz

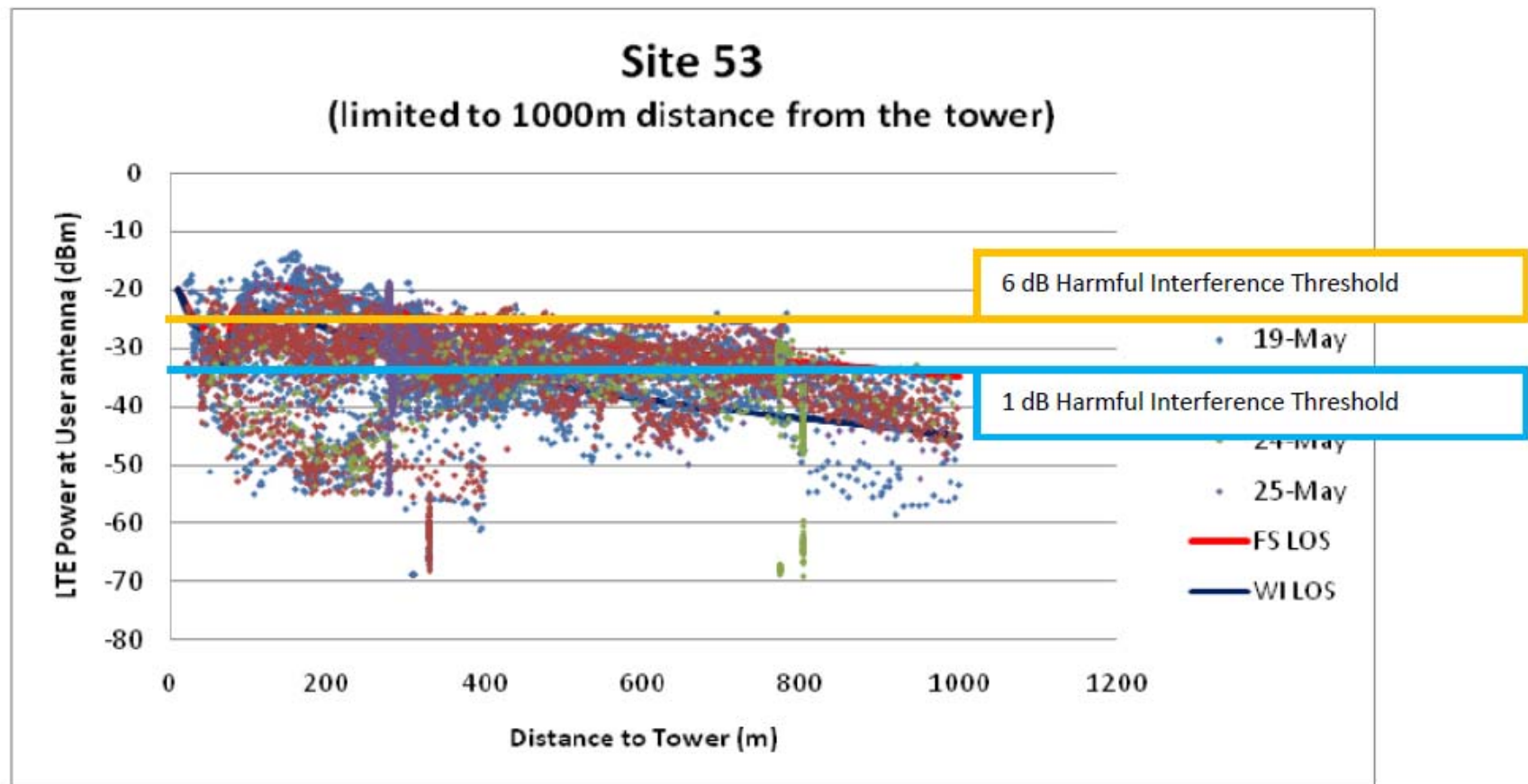
The Lower 10 MHz Proposal Interferes with the Installed User - Base Of General Location/Navigation Devices

- Dispute over harmful interference: power level
 - TWG report shows all General Location/Navigation devices are free from harmful interference at LightSquared power levels of -33 dBm or less (1 dB of C/N_0 degradation)
 - LightSquared is using a power level of -25 dBm as a harmful interference threshold (6 dB of C/N_0 degradation)
- Real world testing in Las Vegas shows devices will experience power levels of -33 dBm and -25 dBm frequently at significant distances from the tower
- This is independent of which propagation model is used. The data stand by themselves.

Annotated Las Vegas “Live Sky” Results

Rural Area

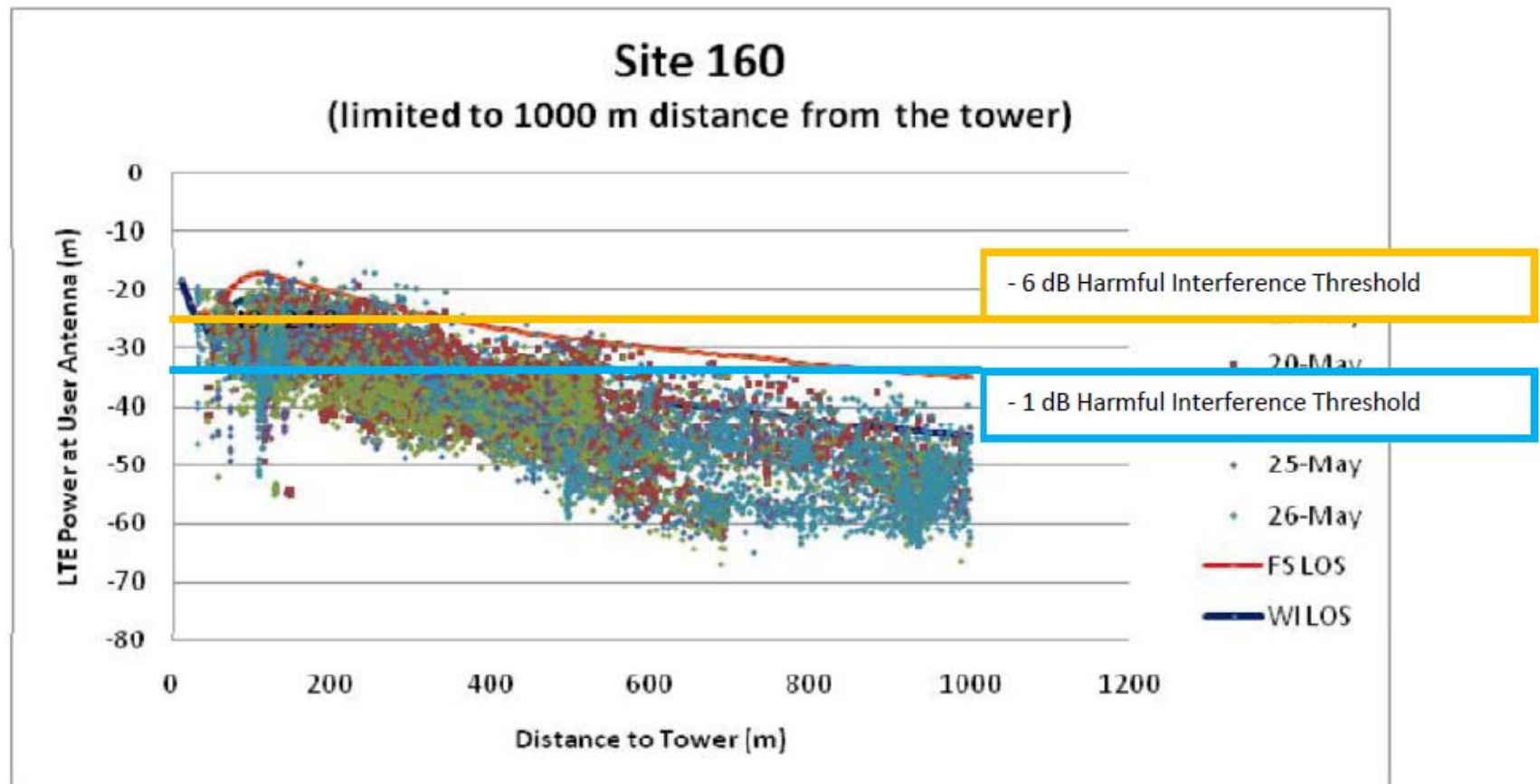
- Many points above interference threshold at large distances show that harmful interference *will* occur



Annotated Las Vegas “Live Sky” Results

Suburban Area

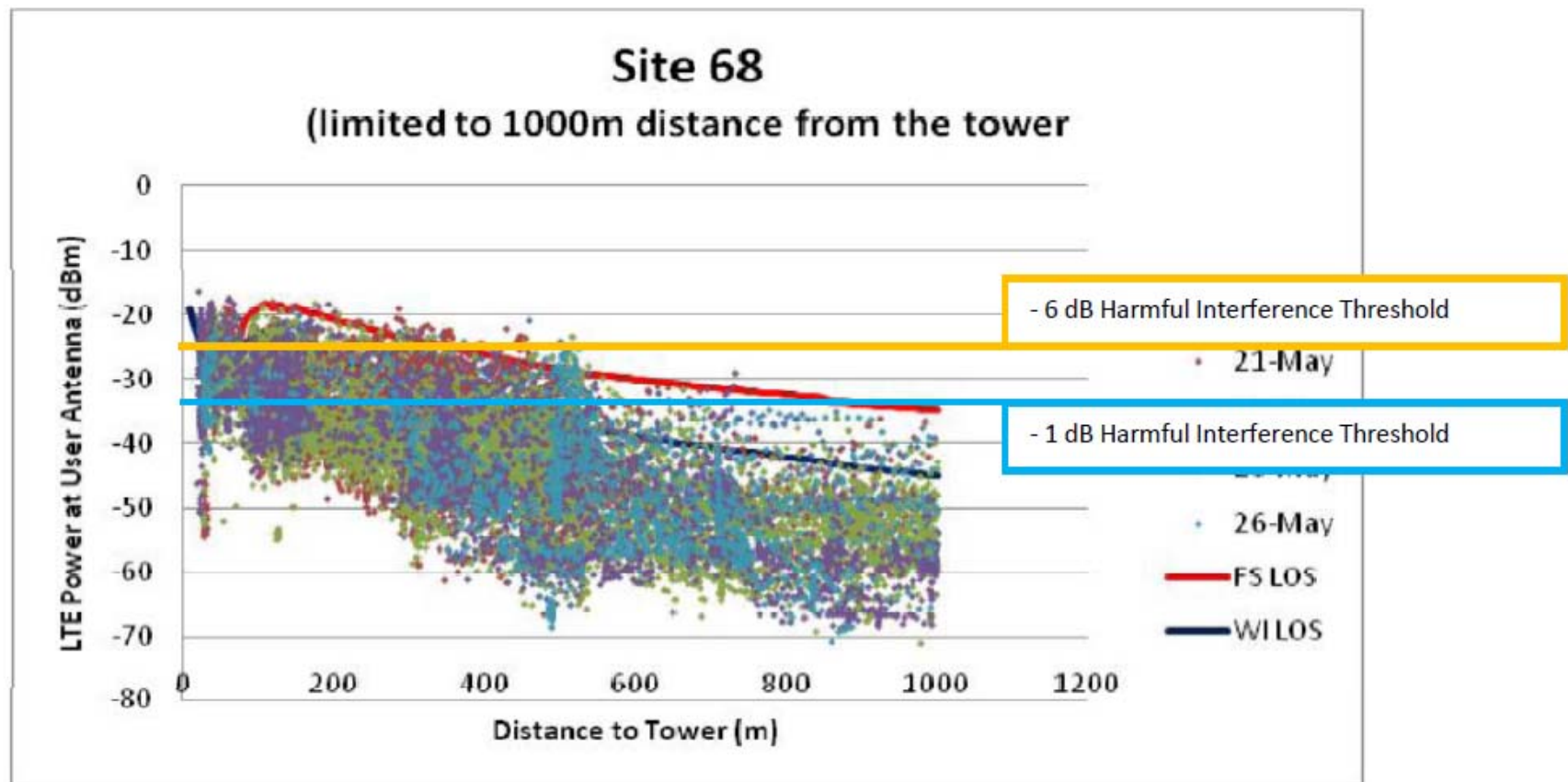
- Many points above interference threshold at large distances show that harmful interference *will* occur



Annotated Las Vegas “Live Sky” Results

Suburban Area

- Many points above interference threshold at large distances show that harmful interference *will* occur



Problems with Lower 10 MHz

The TWG Tests Are Insufficient To Prove That Interference Will Not Occur.

- TWG testing only tested 29 of 53 GLN devices due to time constraints
- Only an interference susceptibility test, and not the full range of the other six GLN TWG tests, was run on lower 10 MHz
- More testing required on lower 10 MHz
 - Test a larger sample of GLN devices, including WAAS enabled as well as models using wider bandwidths (e.g., GLONASS, Galileo). For these devices, at a minimum, an interference susceptibility test needs to be run.
 - For all devices (those tested in the TWG plus any newly tested devices), both uplink and downlink should be simulated simultaneously during the test
 - For all devices, conduct handset interference susceptibility tests at the actual proposed 10 MHz bandwidth
 - For all devices, analyze the aggregate effects of interference from multiple handsets
 - For the devices that show interference, conduct at least the Cold Start TTFF test and the WAAS TTFF test as TWG testing showed devices performed poorly in the presence of the LightSquared signal.

Problems with Lower 10 MHz

The Upper 10 MHz is Still Under Consideration

- Transmission on the upper 10 MHz is disastrous for GPS, yet there is nothing to prohibit LightSquared from using these frequencies
- It is difficult for the GPS industry to focus on the lower 10 MHz proposal when the upper 10 MHz proposal looms as a serious potential problem for the entire GPS industry.
- Cannot engage filter manufacturers on lower 10 MHz proposal when substantiation only exists in LightSquared press releases
- Developing adequate filtering for the lower 10 MHz will still take years to implement and incorporate into products

Problems with Lower 10 MHz

The Handset Issue Has Not Been Studied Sufficiently

- No LightSquared handsets exist – cannot be studied
- Based on basic simulations of a handset signal, the GLN sub-team found 8 devices experienced interference at a range of 1 m or greater
- Effects of multiple handsets in close proximity have not been studied at all, yet highly likely in real life
- Lower 10 MHz proposal requires use of handset frequencies closest to GPS band (1627.5 MHz)

Problems with Lower 10 MHz

The Lower 10 MHz Proposal Raises Concerns for Modernized GPS Signals

- Most GLN receivers are narrowband (front end bandwidths of 2 – 3 MHz)
- Modernized GPS signals, which are increasingly being utilized by GLN devices, occupy the entire RNSS spectrum, requiring wideband front end designs
- It is not clear that these modernized signals are compatible with the lower 10 MHz proposal
- Filter design for lower 10 MHz much more difficult when the entire RNSS band must be protected
- More study and testing required



Aviation GPS and Terrestrial MSS Broadband



September 13, 2011

FAA Certification Overview

FAA certification involves equipment certification and installation certification

- Equipment certification typically completed by adherence to Technical Standard Order (TSO) issued by FAA Aircraft Certification Offices (ACOs)
 - TSO recognizes Minimum Operational Performance Standards (MOPS) created by collaborative industry organizations such as RTCA, which includes domestic and foreign industry, government, and academic organizations
- Installation certification issued by FAA ACOs and Organization Designation Authorization (ODA) authorized by FAA to manage and make findings for type certification programs on behalf of FAA
 - Requires showing of compliance that installed equipment, wiring, etc. complies with FAA regulations and meets needs of aircraft environment (e.g., temperature range, vibration, lightning)

International Harmonization

Key characteristics of FAA TSOs are internationally harmonized in International Civil Aviation Organization (ICAO) Standards and Recommended Practices (SARPs)

- Ensures interoperability of signal, message content, interference mask, etc.
- Allows foreign certification authorities to recognize equipment compliant with FAA TSO in their areas
- Allows FAA to recognize equipment built by foreign manufacturers that complies with TSOs

Historical Perspective

FAA Certified Aviation GPS Receivers Comply with Interference Masks That Predate FCC MSS Rules

- Specifies in- and near-band interference power that an aviation GPS receiver is required to tolerate while satisfying minimum performance requirements associated with satellite tracking
- FAA TSO-C145 / TSO-C146 - RTCA/DO-229 (initially published 1996) Appendix C Figure C-1
 - Current DO-229D (published 2006) interference mask has not changed materially since then
 - First Garmin TSO-C145 receiver became FAA certified in December 2002
- GNSS material, including DO-229 interference mask, was formally adopted into ICAO standards in 2001 (Amendment 76 to Annex 10)
 - ICAO SARPS have since been updated to incorporate RTCA/DO-229D interference mask

Interference Mask

- RTCA/DO-229 Appendix C Figure C-1
 - Initial satellite acquisition is specified as requiring an additional 6 dB of margin
 - Numerous MOPS requirements are tested using interference conditions based on this mask
 - E.g., signal processing, initial acquisition, tracking, reacquisition, data decoding, Satellite-Based Augmentation System (SBAS) message loss rate, position integrity, and position accuracy

RTCA/DO-229D Appendix C Figure C-1

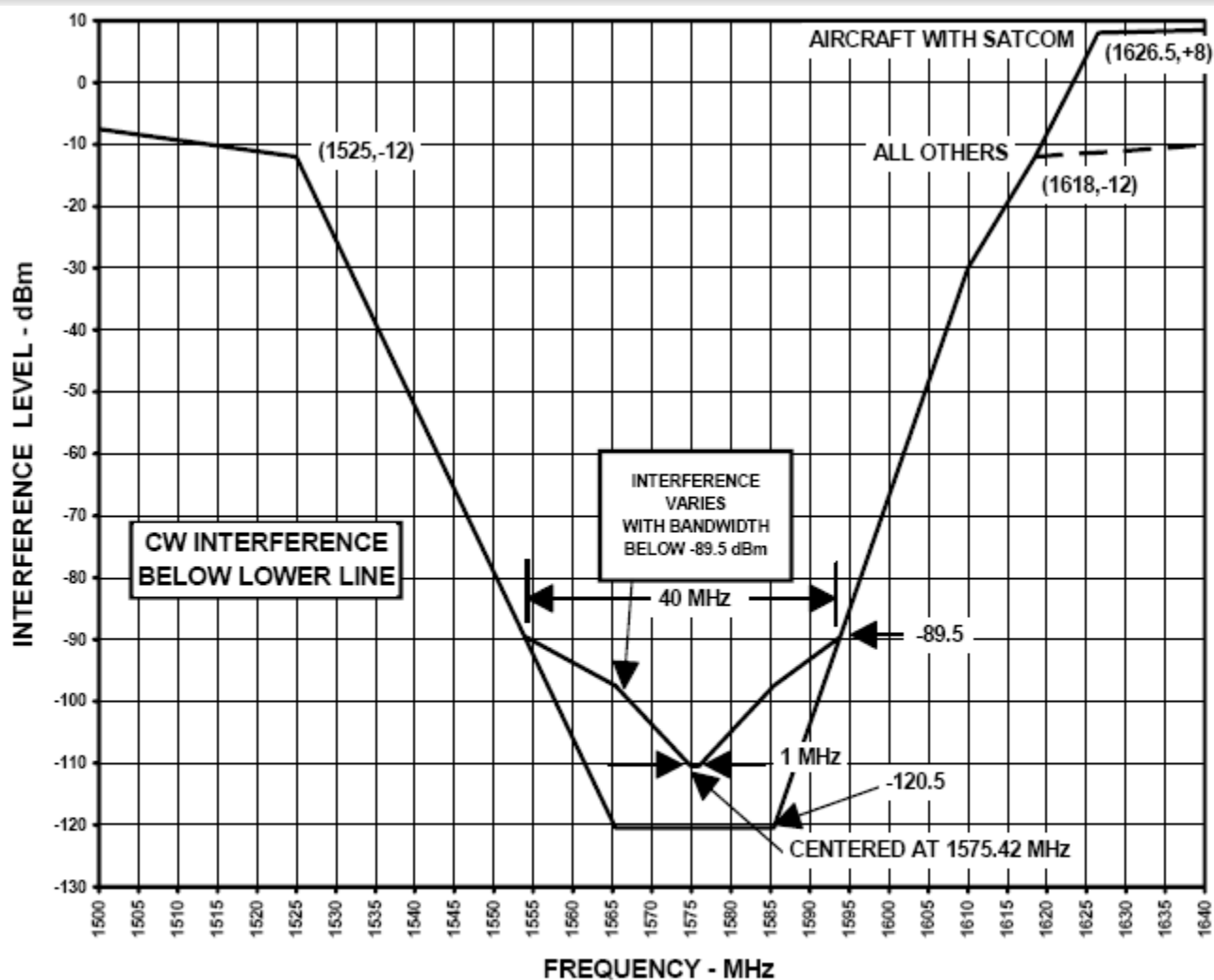


FIGURE C-1 INTERFERENCE LEVELS AT THE ANTENNA PORT

FAA Certified Aviation GPS Receiver Issues

(1 of 2)

Upper 10 MHz Will Cause Complete Loss of FAA Certified Aviation Receiver Function Across Large Areas

- RTCA/DO-327 recommends upper 10 MHz channel operation should not be allowed, but, to date, upper 10 MHz channel has not been taken off the table by any official pronouncement
 - Assuming equivalent isotropic radiated power (EIRP) of 62 dBm per long term evolution (LTE) channel per sector, analysis predicts an aggregate power from LightSquared base stations of -36.6 dBm for an aircraft at 535 meters above ground
 - The DO-229 interference limit for tracking at the upper 10 MHz channel is -85.6 dBm (a 49 dB gap)
 - The interference limit for initial acquisition is 6 dB lower than for tracking, which makes this gap larger (55 dB), for operations on the upper 10 MHz channel

FAA Certified Aviation GPS Receiver Issues

(2 of 2)

Unresolved Aviation Concerns with Lower 10 MHz, Particularly Initial Acquisition

- RTCA/DO-327 study indicated small positive margin for GPS satellite tracking but not necessarily for initial satellite acquisition, which requires additional 6 dB of margin
- RTCA/DO-327 recommends further study of:
 - Determination of lowest path loss for low altitude enroute scenario
 - Confirmation of acceptable receiver susceptibility for GPS initial acquisition and signal tracking in the presence of the 10 MHz bandwidth terrestrial network interference
 - Computation of cumulative probability distribution function for aggregate path loss

Aviation GPS Receivers Without FAA Certification Issues

RTCA/DO-327 Considered FAA Certified Aviation Receivers But Aviation Receivers Without FAA Certification Also Provide Safety Benefits and Must Be Analyzed

- Over 20,000 Garmin installed aviation receivers without FAA certification are in use for Visual Flight Rule (VFR) operations
 - Not tested under any part of Technical Working Group (TWG) process
- Over 200,000 Garmin portable aviation receivers without FAA certification are in use for VFR operations and backup for Instrument Flight Rule (IFR) operations
 - Some tested by TWG General Location/Navigation (GLN) Sub-Team, but GLN tests did not consider aviation in-flight conditions
- Both must be tested using propagation models and aggregate radio frequency interference (RFI) consistent with RTCA/DO-327 to accurately reflect aviation in-flight conditions

Filter Issues

- No workable filters currently exist, only PowerPoint presentations
- Presentations used LightSquared's specifications, not those reviewed and analyzed by GPS manufacturers
- Recent Avago film bulk acoustic resonator (FBAR) filter presentation to FCC only addressed lower 10 MHz
 - Avago business model "based primarily on supplying low-cost filter and integrated filter/[low noise amplifier] LNA solutions for high volume applications"
 - Consequently, filter may not be suitable for FAA certified aviation installation given extreme temperature ranges, intense vibrations, lightning strikes, etc.
- New filters cannot be designed/produced until there is certainty regarding LightSquared's proposed operations
 - E.g., is upper 10 MHz going to be taken off the table through official pronouncement?

Product Cycle Issues

- Cycle to bring new FAA certified products to market is long
 - 10 to 15 years to modify performance standards, design/test products, obtain FAA equipment and installation approvals
 - Design considerations and business certainty cannot tolerate multiple decisions, such as allowing only lower 10 MHz now and then deciding five years later to allow upper 10 MHz operations

Retrofit Issues

- Retrofitting fielded devices is not practical
 - Many portable devices have the antenna and receiver integrated into a single unit and cannot be retrofitted
 - FAA certified installation retrofit may not be limited to antenna replacement alone; receiver replacement also may be required
 - Receiver and/or antenna replacement is costly, particularly antenna replacement in pressurized aircraft